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- USSR -

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(/NOTE/ This article is published by way of discussion.)

The dialectical materialist interpretation of problems of cybernetics -- the science of general regularities and principles of control of complexly organized systems -- is inseparably related to analysis of the Leninist concept "reflection".

Soviet philosophical literature has long posed the question as to whether the quantitative analysis of the basic concepts of cybernetics -- "information" and "control" -- must be supplemented by research into the qualitative aspect of these categories in consideration of reflection as a property of matter. Of the several questions arising from this broad problem area examination of the relationship between the categories "information" and "reflection" is of considerable interest. Two opinions have arisen about this relationship. Some authors consider information and reflection to be basically identical concepts. To others the concepts are very close, but not always equivalent. This problem, ranking high in methodological importance in cybernetics, must be comprehensively discussed. In our opinion, reflection and information are different concepts, designating phenomena distinct from each other. In the present article the author attempts to substantiate his point of view, beginning with the assertion that reflection is a universal property of matter. The article will develop and refine the positions expressed by the author in previously published studies: "O sushchnosti elementarnogo otobrazheniya" /"The Essence of Elementary Representation"/ (Voprosy filosofii, 1960, No 2), and "O vozmozhnostyakh kibernetiki v svete svoystva otobrazheniy materii" /"Possibilities of Cybernetics in Light of the Property of Representation of Matter"/, Filosoficheskiye voprosy kibernetiki /Philosophical Problems of Cybernetics/, 1961.

Characteristics of Reflection and Information

The main features and distinctions of the categories "reflection" and "information" (subsequently we will designate these simply as reflection and information) are determined by their essence. It is important for us to have generalizing characteristics of these concepts, characteristics which would be applicable to all forms of reflection and to all processes of information from elementary representation in inorganic matter to consciousness, and from information circulating in automatic machines to information conveyed through language.

A brief characteristic of reflection in any of its manifestations was given by M. Kornfort: "The process of reflection includes the interrelationship between two particular material processes, where the features of the first process are reproduced in the corresponding features of the second." (M. Kornfort, Dialekticheskiy materializm /Dialectical Materialism/, Moscow, 1956, page 315)

In principle, this characteristic can be taken as the basis with the condition that several refinements are introduced. Henceforth we will proceed from the definition of the essence of reflection given in the following version: reflection is a category signifying the product of action of one material system on another, which constitutes a reproduction in another form of the first system's features in the features of the second system.

This definition is valid for the higher form of reflection -- consciousness, since the fact of consciousness consists in reproducing in the characteristics of processes underway in the brain and central nervous system characteristics of the world external to the brain in an ideal form, in the form of images, concepts, judgements, deductions, etc.

This same definition is valid also for elementary reflection in inorganic matter, since as a result of the direct or indirect action of one material system on another a special product arises in the form of the reproduction of characteristics of the first system by means of varying the changes of the second system's processes, variations which contain characteristics of the represented system and are invested in the form of those processes underway in the representing system.

In practice, in scientific research and in equipment elementary representation takes on the form of changes in instructions to the instrument (change of the angle of rotation of the pointer, changed figures in the counter, deviations from null position of the self-recorder pen, etc.).

We will dwell on the question of the concept of information. We present the characteristics of information given by N. Wiener: "Information is the designation of the content obtained from the external world during our adaptation to it and the accommodation of our senses to it." (N. Wiener, Kibernetika i obshchestvo /Cybernetics and Society/, Moscow, 1958, page 31) Information, according

to N. Wiener, is received in a particularly anthropomorphic form, that is, only in relation to the sensations and consciousness of man. Meanwhile, the characteristics of information presented are more universal in terms of their possibilities, although not at all complete. N. Wiener's definition points to the following important properties of information: a) information arises during the process of control and for its needs (adaptation to the outer world is an act of control); b) the external world is the content of information; c) information is the designation of this content, which does not always coincide with it in form; d) information is taken from the outer world through "sensory organs"; e) information is transmitted from the "sensory organs" to the "mechanism" of adaptation to the outer world. In this sense the definition of N. Wiener can successfully be used for all living organisms and for technically controlled equipment, if we refer to the process of adaptation of any controllable system in general to changing external conditions. The indisputable merit of this definition is the fact that it points to the inseparable relationship between information and control.

An important specific feature of information not mentioned in N. Wiener's definition consists of the fact that information reflects not only the concept of events external to the system being controlled, but also events underway in constituent parts of the system itself (feedback information, command information). It also should be noted that information expresses not only the content of presently occurring events, but also of events which will yet occur in the future (cf I. A. Poletayev, Signal, Moscow, 1958, page23). The general charcteristics presented of course do not exhaust the essence of relection and information, but they assist in discovering the general features and distinctions of these categories.

Some General Features of Reflection and Information

Reflection and information have an important feature in common: they do not exist apart from material processes and at the same time they are not identical with a single form of matter or movement.

Since reflection is reproduction in another form of the characteristics of one material system in the characteristics of another material system, it cannot exist: a) without the existence of at least two material systems; b) without the interaction of these material systems, that is, without the transformation of one form of motion into another; c) apart from processes occurring in the reflecting system. Thus, human consciousness is impossible without its interaction with the external world (nature and society), without physiological processes which are underway in its central nervous system and brain. At the same time, a higher form of reflection -- thinking -- is the reproduction of characteristics of the material world in an ideal phenomenon -- thought. Thought is not

to be reproduced either to matter or to energy, although it cannot exist apart from material processes underway in the brain. Consciousness is a property of highly organized matter. Similarly, elementary forms of reflection cannot be reduced to any forms of matter and energy, since they themselves are forms of change of material systems stemming from their interaction.

Information is stored either in the memory of a man, animal, or in the "memory nodes" of machines, and is conveyed either by speech, the nervous system, or along communication channels of technical equipment -- inseparably linked to matter and motion. It does not exist apart from material processes. The transfer of information is possible only due to physiological, physical, chemical, or other material processes, and its storage is associated with relatively stable combinations of states of brain cells or of elements of machine "memory nodes".

In addition, information is a special form of the relationship between material systems and processes, and, therefore, it can never be called a kind of matter or energy. The following statement of N. Wiener is of interest in regard to this question: ". . . A large computer, be it a mechanical or an electrical system or the brain requires a large amount of energy, which is expended and diffused in the form of heat . . . However, the energy expended in an individual operation is infinitely small and can by no means serve as the proper measure of equipment performance. A mechanical brain does not produce thought, 'as the liver produces bile,' which was asserted by previous materialists, and does not release it in the form of energy, as muscles do. Information is information, and not matter and not energy. The materialism which does not recognize this cannot be viable at the present time." (N. Wiener, Kibernetika /Cybernetics/, Moscow, 1950, page 166)

The content of N. Wiener's scientific works points to the fact that in the field of natural science he is an elemental materialist and even sometimes a dialectician (at the conclusion of his book Kibernetika he convincingly presents the problem of the transition of quantitative changes to qualitative within a specific area of phenomena). But this elementalness determines the inconsistency of his materialism mainly in examining phenomena of public life.

The ascription by N. Wiener to all previous materialists of the sins of vulgar materialists can be explained by the misunderstanding evidently which stems from his inadequate familiarity in matters of the scientific history of philosophy. The remark of N. Wiener, made in regard to "modern materialism", evidences on the one hand his personal interest in recognition by this materialism of the idea that information cannot be reduced to matter and energy, and on the other hand, the exaggerations (caused by the whole tenor of life of the scientist in bourgeois society) of "modern materialism", which official Western philosophers very readily represent as vulgar materialism.

Modern materialism is dialectical and historical materialism, always strictly differentiating matter and motion from the phenomena which are of material origin, but which cannot be identified with matter, such as, for example, thought.

The idea of N. Wiener that "information is information, and not matter and not energy," is somewhat contradictory. From the philosophical point of view it is imprecise, although it has a certain positive natural-science content.

Why is it invalid from the point of view of dialectial materialism to define information through negating its affiliation with matter and energy? In the first place, such a negation does not provide a definite answer to the question, what is information (in logic definitions derived through negation of any features of a specific object are not considered as fully valid); secondly, and this is the important thing, with such a definition an unsubstantiated shift of the natural-scientific characteristics of one of the properties of information can occur to the level of a basic gnoseological question. As is generally known, main question of gnoseology has to do with the opposition of matter and consciousness as primary and secondary. "Of course," wrote V. I. Lenin, "the opposition of matter and consciousness is of absolute significance only within the limits of a very restricted region: in this case exclusively within the limits of the basic gnoseological question, how can we recognize the primary and how the secondary. Beyond these limits the relativity of this opposition is obvious." (Collected Works, Vol 14, pages 134-135)

It must be noted that the opposition of the primary and the secondary is observed also between material objects, for example, the opposition of the primacy of cause and the secondariness of effect. But this opposition no longer has to do with the gnoseological basic problem and, of course, does not have such an absolute sense as does the opposition of matter and consciouness in gnoseology.

If information is defined as neither matter nor energy, then we must answer the question: what is it in relation to matter? Once information is no longer primary at the level of the main gnoseological question (is not matter), it must be secondary, that is, that which in gnoseology is called ideal. However, no one has clearly designated information as an ideal phenomenon. But defining information only by negating its affiliation to matter is so imprecise that it can provide cause for assertions that between the material and the ideal a third entity -- information as such -- exists. In gnoseology this third entity is not given: the immaterial is the ideal.

In our opinion, such an error in defining information by negating the materiality of its existence is found in a discussion by A. Kharkevich, who wrote: "The first of the features of modern information consists in that, although it is an immaterial object, it is given quantitative measure; a sufficiently universal definition

of amount of information has been introduced." ("Information and Technology", Kommunist, 1962, No 17, page 93) We see that in this case also information is designed as an immaterial object (does this mean, ideal?).

Above all it must be emphasized that there are no immaterial objects in the world. V. I. Lenin said that there is nothing in the world besides matter moving in space and time, that the absolute opposition of the material and the ideal beyond the limits of the basic gnoseological question is relative. When we speak of the reality of the information process, then we always have in mind a process transpiring between material systems. Any process of information and any information has reality insofar as the information is absorbed in some material process.

Thus, information in public life has reality only because it is absorbed in material forms of an audible language, writing, magnetic tape recording, sketches, figures, signs, etc. Information in the life activity of the human or animal internal organs is absorbed in nervous impulses, biochemical processes, etc. Information in the machine is absorbed by electrical impulses, etc. Apart from material absorption information has no reality. The reality of an idea is also determined by the material form of its content. All this indicates that one can never define anything in the objective world (including also information) as an immaterial object.

It is improper to define information as an "immaterial object" for still another reason, that the concept of information existing in modern science includes genetic information, machine information, physiological information, which are not associated with ideal phenomena.

It must be said that in all his special discussions and mathematical arguments N. Wiener and other cyberneticists-scientists work from the material reality of the information, represented in the form of processes occurring in material systems.

We now turn to the question of the positive natural-scientific content of the idea of N. Wiener. We find this positive content in his assertion that information can never be reduced to any form of matter or energy, therefore, it is a special form of common communication, and a special form of the interrelationship of material objects in a control process.

In order to convey or store information and in general for it to exist as such, a material process is necessary, that is, a certain amount of matter in motion is required, although information itself is not reduced to any form of matter or motion. Thus, however we might examine the pages of a book, figures or sketches, we would not be able to extract from them information as a certain mass of special substance, as a section of a field or a portion of energy, although we would discover in them some kind of material structure reproducing the structure and content of those thoughts which the authors of the book, figure, or sketch desired to convey. However much we might examine a magnetic tape before and after

speech was recorded on it, we would not be able to extract from it information as a certain form of matter or motion. But after the message is placed on the tape something new happens: its magnetic structure is altered, and this new structure is information, since it corresponds to the structure of speech and, consequently, to its content. This content of speech has a material reality because it is absorbed in a material form, in this case in the magnetic structure of the recorded tape.

* * *

The most important characteristic of reflection is its secondariness in relation to that represented. Here we must note one fact of fundamental importance. We speak of the essence and nature of the secondariness of reflection in the inanimate world, when both the primary and the secondary are different forms of matter and motion, and also of the secondariness of the higher form of reflection, when consciousness, the ideal, is secondary in relation to matter as such.

The secondariness of consciousness in relation to matter constitutes the central problem of gnoseology. The secondariness of elementary reflection in inorganic matter essentially reduces to the problem of cause and effect, to the problem of the reproduction of elementary representation, invested in a physical, chemical form of motion of matter in relation to the material system represented. This secondariness basically takes on a natural-scientific and philosophical sense of secondariness, the reproduction of effect in relation to cause, when both the primary and secondary are material formations.

Secondariness of consciousness in relation to matter shows a gnoseological sense of secondariness of the ideal in relation to the material. In this case we also have the relationship of cause and effect, but this relationship does not exhaust the main problem of gnoseology: the relationship of matter and consciousness, which is caused by the watershed between materialism and idealism in their conflict in the area of the basic problem of philosophy.

If one considers the different content and nature of secondariness of lower and of higher forms of reflection, then the universality of the law of reflection formulated by V. I. Lenin becomes obvious: ". . . Representation cannot exist without that represented, but the represented exists independently of that representing." (Collected Works, Vol 14, page 57)

The essence of this law consists in the following: firstly, reflection always is secondary in relation to that being reflected, since it exists without it and independently of it; secondly, this secondariness and, in particular, the complete adequacy of reflection in relation to that being reflected is caused by the independence of the reflected from the reflecting. In the opposite case, reflection will have as its content not only the characteristics of

that being reflected, but also the characteristics of that doing the reflecting. On this basis, the reflecting elements of a controlling system must have such a structure in order to exclude as far as possible their effect on the content of reflection.

As far as information is concerned, it is based on reflection, does not exist apart from it and has the same content as does reflection: characteristics of the objects being reflected, of which communication is being conveyed. The reproduction of information in relation to reflection consists in that reflection does not depend on information, but information depends on reflection, it does not exist apart from it. Speaking in the language of physics, reflection, as a special product of the action of surrounding conditions on the reflecting element of the controlled system, modulates the material process specific for the specific channel of communication of the controlled system, which process as will be seen below can be the sign of reflection. By modulating or converting reflection into information we will designate change with time of any parameter of a physical or physiological process in the communication channel, occurring under the action of reflection in the reflecting element of the controlled system, here this change is carried out in accordance with change in reflection content.

The changes of the process as to content that are modulated in the communication channel depend on reflection and do not exist apart from it. Reflection itself does not depend on the process changes modulated by the communication channel. The process of converting reflection into information indicates that information cannot exist without the act of reflection, but the act of reflection can be carried out without the process of modulation, that is, without converting reflection into information circulating in the communication channel. When information is derived from a higher form of reflection, from ideal phenomena, it is secondary in a certain sense and at the gnoseological level, as the ideal is secondary in relation to matter.

We note still further another general characteristic of information and reflection, their isomorphism.

The isomorphism of reflection consists in that the introduction between the reflected and reflecting systems of some numbers of mediatory systems ultimately changes only the form of reflection, but not its content (if we do not consider possible interferences). The content of reflection (characteristics of the object being reflected) does not depend on the form of its manifestation.

Thus, reflection of the temperature of a physical body can have various forms: difference in length of mercury columns, difference in angle of rotation of the needle of a galvanometer secured to a thermocouple, change in the curvature of a bimetallic strip, perception of warmth by the hand. In this diversity of forms the content remains the same: a certain temperature.

In technology and scientific research this isomorphism of reflection affords the selection of mediatory systems most convenient to produce such forms of reflection which can be used as instructions to instruments, photographs, records of curves, and so forth. The isomorphism of reflection makes possible the transformation of reflection from a form not accessible to our sensory organs to a form that is accessible. For example, through photography we can study the properties of ultraviolet rays invisible to the eye.

The isomorphism of information affords the possibility of transforming, of converting information from one physical alphabet to another with retention of its contents. For the content of information it does not matter which physical or physiological process is used to convey the information. The mechanism of information transfer has no relationship to its content (under the condition that it does not introduce substantial distortions). The isomorphism of information becomes manifest upon examination of its signal character, which we will discuss below.

Several Differences Between Information and Reflection

As has already been said, the content of information and reflection comprises characteristics of the external world and events occurring within the systems being controlled. However, in distinction to reflection, which is a special product of the action of one material system on another (with all degrees of complexity of these systems), information is a special form of a general bond under the special conditions of the controlled system or association of controlled systems -- a bond of the control apparatus of the system being controlled with any of its elements and the external world, and also a bond between the control apparatus of different or similar systems. The control apparatus of a complexly organized system we designate as the totality of system facilities with the aid of which selection of system reactions to changing external conditions are accomplished and which activates the corresponding system elements implementing this selection.

In the controlled system information links reflection of the external world to the reflecting elements, and also reflection of the states of the system elements with the control apparatus, and the control apparatus with the executing elements of the system. In this way, information as a special form of general bond, whose reality is absorbed in material processes, is the action of reflection on the control apparatus, and the action of the control apparatus on the "behavior" of the controlled system.

The process of information has at it were two "poles", which do not exist apart from each other. One "pole" is reflection of the fact or controlled process of system functioning, and the other -- the control apparatus of a complexly organized system.

Let us examine the concept of control. Control is the process of improving and adapting a complexly organized system to changing external conditions, which process must be realized in such a manner that the system itself is not destroyed and its functioning halted.

Sometimes control designates any random interaction leading to any kind of result. Thus, in popular books on cybernetics we find presented examples of "control" by movement of a snow avalanche, brought about by a stone lying on the mountain slope.

Here is how control is characterized in one study on methodological processes of cybernetics: "In its most general form control can be defined as the ordering of a system (by system we mean any object of the real world), that is, putting it in order in accordance with some objective regularity." (I. B. Novik, "Several Methodological Problems of Cybernetics," Compilation: Kibernetiku na sluzhbu kommunizmu /Cybernetics at the Service of Communism/, Moscow, 1961, page 35) According to this definition, control must be considered as putting any object of the real world in order in accordance with some objective regularity. This concept differs from one of the main positions of cybernetics in that control is possible only under a definite organization of matter.

If we take the point of view of I. B. Novik, then we must acknowledge that control is, for example, "the putting into order" of a certain amount of water in accordance with the objective principle of water freezing at a temperature lower than 0° Centigrade (at normal atmospheric pressure), that is, the transformation ("ordering") of water into ice crystals. We also must regard control as ordering the motion of the planets in their orbits around the sun, since the motion of the planets "is ordered in accordance" with the objective laws of celestial mechanics. In short, accepting this point of view, we will never discover a phenomenon which is not control.

The process of control cannot be realized anywhere and under any circumstances, but only in complexly organized material systems, capable of being accomodated to changing conditions. It is enough to pose the question: did control exist before life appeared on earth -- which immediately shows us the total precariousness of the arguments that state that control is related to any process occurring in inanimate nature. To assert that control exists in processes of inanimate nature results in reviving helozoism, but only in the language of modern science. The process of control can never be reduced to changes of any object, occurring in accordance with an objective principle, since this process, in addition to change, contains something that is not characteristic of most objects in the material world. This something can be called the active principle, arising historically together with the manifestation of the simplest forms of life.

Since control is the process of improving and accomodating a complexly organized system to changing external conditions, then

control itself, essentially, is also a form of reflection, reflection of a higher order -- active reflection.

The activeness of reflection in the form of control assumes a moment when facts are compared and a "plan" of action of the system in the form of a series of commands to the executing elements is chosen. This moment of comparison and selection is related to an operation of some generalization, carried out in the control apparatus of all controlled systems. We emphasize that we speak here of comparison of facts, which act can be the moment of the simplest, the "embryonic", but still a generalization.

As to the ability of the brain to make generalizations of the highest order we need not speak, since this is a generally accepted truth. As far as the moment of generalization in controlled systems of a lower order of organization is concerned, this question calls for clarification. By the moment of generalization in the control process we will signify the same reaction of the controlled system to similar situations, and also the comparison of information on the facts in the control system and the selection of the optimal solution of the task of adapting the system to the new conditions.

Thus, "phototropism" of mechanical "worms" is elementary control, since a still very primitive, but all the same a generalization is expressed by the command: upon change in the position of the light source always follow after it! There is no need to state that in technical devices such "generalizations" are previously built into the control apparatus designed by its creator -- man.

The phenomena of irritability, unconditioned an conditioned reflexes in living organisms include moments of comparison and some primitive generalization, necessary in the processes of controlling the life activity of these organisms and expressed in the process of prolonged natural selection.

Information at the entrance of the control apparatus has as its content reflection of the external world without the moment of generalization. Information at the exit of the control apparatus always contains the moment of generalization in the form of a command for actuation of the system, that is, it has as its content not only facts (external and internal events), but also a distinctive evaluation of these facts in the form of a reaction of the controlled system to the changed external conditions. Therefore, we must look somewhat critically at the assertion of N. Wiener: "No action higher than reporting can thus result in an increase of mean information." (Kibernetika, Moscow, 1958, page 87)

If we approach the problem from formal positions, information really contains a certain amount of knowledge of facts, which can never be increased through any mathematical transformation. The certain number of facts remains a certain number of facts. However, the process of control is not reduced to a

summation of facts. Facts can be compared, and their comparison yields something new, not directly stemming from each fact taken separately or from the arithmetic sum of the facts.

The control process consists in part of "assimilation" of the facts through their comparison and, subsequently, some generalization. The process of control is the process of generalizing information entering the control apparatus, by conversion from facts isolated to facts related, or properly, to a relationship of facts. Engels wrote that the eye of an eagle is sharper than the eye of man, but man sees more than the eagle. In more complex and advanced controlled systems the control apparatus has great possibilities of generalizing the incoming information on facts.

How is information realized, that is, a special form of relationship between reflection and the control apparatus, on the one hand, and between the control apparatus and the process being controlled, on the other? The least economical and most complex would be the direct transfer of reflection from the reflecting element of the controlled system to its control apparatus. Such a method would require very complex communication channels and an extremely cumbersome and complex control apparatus, capable of receiving, treating, storing, and using as the need arises these reflections.

The first controlled systems in history -- living organisms -- during the process of prolonged natural selection have developed the most economical and effective means of communication between the sensory periphery and the central nervous system through impulses -- irritations of nerve tissues, which constitute the signal.

What is the signal? The signal is the physical or physiological substitute for the reflection, existing with it depending on content (and, therefore, depending on the object of reflection) and expressed in the form of change of a material process occurring in the communication channels, more precisely, expressed in a difference of states of the communication channel. Reflection, as has already been noted, is converted to information through modulation of the process in the communication channel and through development of the signal.

Often serving as the signal is a sign of reflection, which affords a certain increase in the passing capacity of the communication channel, obviously, nervous impulses are physiological signs of reflections in the form of sensations, signs, produced on the objective basis of prolonged natural selection and designating the compatibility of the reactions of the organism's organs to the changed conditions. Reflection of itself can never serve as a sign of that being represented. Reflection reproduces the properties of the represented in another form.

In technical devices the signal-sign can be exemplified in the system of transmission of information from a space ship to earth control stations by means of telemetric equipment, when a signal is transmitted at a conventionally changing frequency,

and the given frequency is related to specific instructions to a specific instrument. An example of a signal-sign can be the signal of image scanning in television transmission or the signal entering at the receiving station of a phototelegraph, etc.

It must be emphasized that the signal is transmitted along the communication channel on the basis of the property of the reflection of matter. But in the process of signal transmission this property is used only to convert the signal, to transform if from one physical or physiological alphabet into another. Under such a conversion, signal characteristics in one alphabet are reproduced into the signal characteristics of another alphabet.

Let us present still another characteristic of the signal, which underscores the signal nature of information and inseparability of signal and control: "We must particularly note the fact that the signal as a physical process inherent to information, that is, maintaining correspondence with a given event, always exist only within the limits of a certain organized system. This system, by virtue of its properties, makes possible the realization of all the signal properties, of which the most important is that the signal is used for control, that is, to produce a reaction or a response to change in the outer environment. Apart from the organized system a signal can exist and can store its physical properties, but loses all the properties of a signal, it is deprived of information, the link between the event and the reaction, is bereft of the possibility of 'comprehending' a signal, and of using it to produce a reaction." (I. A. Poletayev, Signal, page 33)

Thus, apart from an organized, apart from a controlled system processes can exist which exhibit all the physical properties which a signal has in the controlled system, but lacking the most important property of the signal -- conveyance of information which is used for control. In addition, under any conditions in inorganic matter reflection can exist, which is not necessarily associated with control.

In this connection, we must examine still another definition of information: ". . . by saying that reflection is the substrate of information, we can proceed to a concise examination of information itself. Here we can on the basis of such an approach consider information even in a qualitative sense. Information is ordered reflection. Thus, noise naturally will be unordered reflection. With such a formulation of the question, in our opinion, several difficulties existing in information theory immediately disappear." (I. B. Novik, "Several Methodological Problems of Cybernetics," Compilation: Kibernetiku na sluzhbu kommunizmu, page 40)

Designating information as ordered, and noise as unordered reflection still does not at all yield a clear answer, which would result in "several difficulties present in information theory immediately disappearing."

The secret of information does not at all lie in the orderedness of reflection. In inorganic nature we can find naturally ordered reflections (for example, the ordered reflection of the rotation of the moon about the earth in the form of regular high tides and low tides of the ocean, the ordered reflection of the atmospheric change of day and night with regular breezes from the land to the sea and reverse, etc.), but neither of these examples produces information.

Information is an object of transmission, storage, and treatment. Apart from these processes information is impossible. All these processes are engendered by control, which is inseparably related to them and organizes them. In the elementally occurring phenomena of inorganic nature elementary representations do not constitute an object of organized transmission, storage, and still less so treatment.

Information is the content of reflection (characteristics of the object represented) plus the transmission of this content along the communication channel, plus the treatment of the reflection content in the control process through comparison, generalization, etc.

Of itself no ordering of reflection yet constitutes information, if reflection is not associated with control, if it is not organized by control for the needs of this control. It is precisely the bond between reflection content and the control apparatus or the control apparatuses each with the other that is information.

The fact that this bond is realized through a signal, and that the signal is based on the property of reflection of matter, that reflection is the substrate of information, does not at all mean that information itself is reflection, but only the ordered /entity/.

As already mentioned above, the content of information can be events which have not yet occurred, but which will occur in the future. If we consider the processes within the controlled system, then it can be established that after information on external and internal situations and several generalizations on these facts in the control apparatus the act of the system's reaction to the change external and internal conditions follows, which act arises under the influence of the information-command from the control apparatus.

The information-command is information on what has not yet but will in a certain interval of time transpire in the controlled system. In this case, the content of information is the characteristic of future events.

Is such a statement true for all forms of reflection? No. If we do not consider the technical use of reflecting processes, then elementary representation in inorganic matter (even elementally ordered) cannot have as its content characteristics of future events. Without controlled processes we cannot have active

reflection, and without active reflection we cannot have information.

In conclusion, we will dwell on the difference between quantitative evaluations of information and reflection, the difference between the concept of "quantity of information" and "degree of adequacy of reflection".

Information is subject to measurement and quantitative estimation. Without the quantitative analysis of information it is impossible to solve seriously problems of designing communication channels, or to study the organization of control of complex systems. Therefore, information theory works from the concept of quantity of information.

The concept of quantity of information is related to the concept of organization of the system. In cybernetics the concept of quantity of information is related to the concept of entropy. Here, in cybernetics the quantity of information in the system is taken as the measure of organizedness of the system, and the system's entropy is taken as the measure of the disorganizedness of the system.

Increase in the physical entropy of a material system signifies the obliteration of differences in the energy states of its elements, a rise in the amount of energy which cannot be converted into work. Increase in the physical entropy of a material system restricts the possibility of the reflection of one of its elements by another, since in the system where several forms of motion are not converted into others, that is, where work is absent, nothing happens. Once there is no action, there are no events, and this means that there is neither an internal process of reflection, as, incidentally, is the case for any other process.

As far as organized, controlled systems are concerned, increase in entropy in these systems leads to a breakdown in functional-type relationships between system elements and the system as a whole, to a disjunction of the states of the system elements, and to an increased independency of these elements one from the other, and from the system as a whole. This signifies the "resorption" of the organization itself as a complex form of interaction of both the functional dependency of the parts and the whole.

In the theory of reflection we do not find the concept of quantity of reflection, similar to the concept of quantity of information, because in reality nothing corresponds to quantity of reflection, it is not a measure of the ability of matter to be reflected, since all matter has the property of reflection, independently of how highly organized the matter may be. Reflection is reproduction in another form of the characteristics of the object being represented, that is, reproduction in another form of some fact. To speak here of the quantity of reflection of some fact makes no sense. If the fact is the temperature of air, equal, for example, to -20°, with whatever instruments it is reflected, we will have the figure close to -20°. No increase

or decrease in reflection will occur. The figure itself, -20°, does not reflect the quantity of reflection, identical to the quantity of information on this temperature. And however we might analyze the process of air temperature measurement we will not find occasion to introduce the concept of quantity of reflection, but we will find it necessary to determine the wholeness of the reflection, that is, the degree of its adequacy.

The degree of adequacy of reflection indicates how fully it reproduces the characteristics of the represented. This degree can be expressed quantitatively. Thus, for example, in instrumental measurements there are methods of calculating errors of instrumental readings, which makes possible by means of not at all adequate reflections to find the adequate reflections of those parameters which are being measured with the instruments.

The difference between reflection and information in this sense consists in that increase in the entropy of an organized system, in other words, the process of its disorganization, does not designate the complete disappearance of reflection. In elementary forms reflection of the "external" world can occur also in a disorganized system.

N. Wiener undoubtedly was wrong in his pessimistic conclusions that as it were an inexorable rise of entropy in the world as a whole is underway. In the universe such a situation has never been and can never be the case when action is absent, and, consequently, reflection.

Information derived from increase in entropy can disappear in a specific organized system entirely, if breakdown of the controlled system's organization sets in, but the ability to reflect cannot disappear.

In conclusion, we can state the following:

1. Reflection and information are related, but still distinguishable categories.

2. Reflection is the category designated the special product of action of one material system on another, which constitutes reproduction in another form of characteristics of the first system in the characteristics of the second.

3. Reflection can never be a sign of that being reflected.

4. Information is a special form of a general bond under special conditions of a controlled system or associations of controlled systems. Information is the bond of the control apparatus of the system being controlled with any of its elements and with the external world, and also between the control apparatuses of different or similar systems, a bond which can be realized through the agency of a signal -- the sign of reflection.

5. Information arises at a certain level of organization of matter, when control processes occur. Information and control are twin categories, each of which cannot be manifest without the other.

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